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WATER QUALITY EVALUATION OF ROBLIN LAKE

1974

Ministry
of the
Environment
Ontario

The Honourable
William G. Newman,
Minister

Everett Biggs,
Deputy Minister

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WATER QUALITY EVALUATION

OF

ROBLIN LAKE

1974

BY

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Water Resources Branch

Ontario Ministry of the Environment

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ABSTRACT

A water quality evaluation was conducted on Roblin Lake to assess the degree of enrichment relative to that observed four yearsearlier.

The average seasonal Secchi disc value (3.8m) showed a slight improvement over the 1970 value of 3.2m. Secchi disc values correlated well with euphotic zone chlorophyll a values (r = .65).

On the present study total phosphorus values showed a slight increase while silica values were considerably higher than values for 1970.

Total Kjeldahl nitrogen was lower through the water column but higher at the 10.0m depth in the present study.

No significant changes in hardness, alkalinity, conductivity, dissolved oxygen, pH, colour, ammonia or bacteriological parameters were seen upon comparison with the 1970 data.

Roblin Lake with an estimated loading of 0.117 gms. total P m^{-2} yr^{-1} and a mean depth of 3.1m along with a flushing time of 2.8 years was classified as mesotrophic according to Vollenweider's total phosphorus-mean depth divided by flushing time relationship.

In terms of the parameters evaluated Roblin Lake has not significantly changed in enrichment status since 1970.

INTRODUCTION

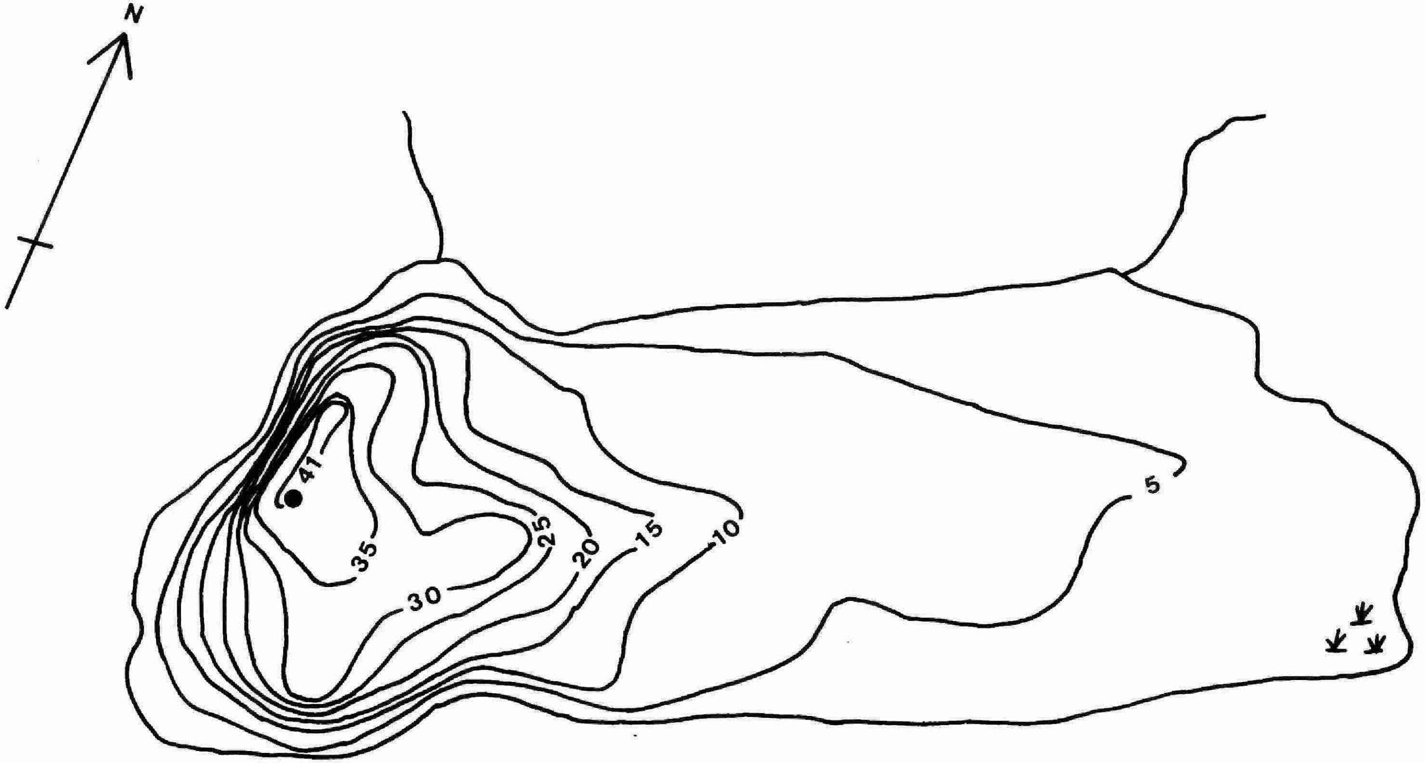
A water quality evaluation was conducted on Roblin Lake in 1974 to assess the degree of enrichment relative to that observed 4 years earlier (Michalski and Hopkins, 1970).

GENERAL DESCRIPTION OF THE STUDY AREA

Roblin Lake is located in the Township of Ameliasburg, Prince Edward County (Figure 1). Physical characteristics are tabulated below.

Maximum depth	12.8 m
Mean depth	3.0 m
Volume	2.77 x 10^6m^3
Surface area	0.85 km^2
Drainage area	2.38 km^2

The lake is located in a drainage basin of blue, very fine crystalline to sub-lithographic limestone in excess of 100 feet in thickness which is overlain by Farmington Loam - a shallow soil of drift and weathered limestone. The lake is in a hollow bounded on the north by a limestone escarpment 400 feet above sea level and on the other three sides by limestone table-lands attaining the same elevation. (Michalski and Hopkins, 1970). Roblin Lake has a small drainage basin (2.38 km^2) relative to its surface area (0.85 km^2). An O.W.R.C. report (Coles, 1970) stated that the topography immediately adjacent to the lake indicates that the only water available for storage must fall on the catchment area. Precipitation must reach the lake in the form of surface runoff or ground-water seepage, but it appears very unlikely that any water reaches the lake from outside the topographic drainage area since most of



FIGURE; I

ROBLIN LAKE – AMELIASBURGH TWP
PRINCE EDWARD COUNTY
APPROXIMATE LOCATION OF SAMPLING STATION IN ROBLIN LAKE – 1974
DEPTH CONTOURS ARE PRESENTED IN FEET

587 0 587 FEET

the immediately surrounding level is at a lower elevation than the lake. Roblin Lake is used almost exclusively by local residents and cottagers for swimming, boating, fishing and other water oriented recreational activities. Approximately 50 cottages exist on the lake's perimeter running from the southwest corner along the west and north shore to the extreme easterly end of the lake. The south shore is undeveloped with the exception of one farm.

PARAMETERS EVALUATED AND SAMPLING TECHNIQUES

Physical, chemical and bacteriological parameters were monitored on a bi-weekly basis from May 16th to October 1st, 1974 at one deep water station (12.8 m). Samples were taken at surface, 2.0, 4.0, 6.0, 8.0, 10.0 and 11.6 m.

Indices of light penetration were made with a Secchi disc. Temperatures were taken by immersing a standard laboratory thermometer into the Van Dorn water sampler immediately after a water sample from each depth had been taken.

Analyses for turbidity and colour were done according to Outline of Analytical Methods by the Laboratory Branch (1974).

Chemical Parameters

Dissolved oxygen profiles were established by the Winkler Method. Manganese sulphate and alkaline azide were added in the field. Addition of sulphuric acid and subsequent titration with sodium thiosulphate were done in the laboratory. Samples for nutrients, alkalinity, conductivity, hardness, sodium, potassium, silica, iron, manganese, magnesium and pH were collected with a 6 l. Van Dorn water sampler and returned to the laboratory. Analyses were done according to Outline of Analytical Methods by the Laboratory Branch of the Ontario Ministry of the Environment (1974).

Biological Parameters

Samples for chlorophyll a analysis were dealt with in the same manner as previously described for chemical parameters.

Bacteriological Parameters

Bacteriological samples were obtained at the deep water station at each depth on a monthly basis using a sterile 237 ml air syringe (Daval Rubber) mounted on a device based on a modification of the piggy-back sampler of Sieburth (1963). Samples were kept cool in transit to the Ministry of the Environment Laboratories and analyzed within 24 hours of sampling.

RESULTS

PHYSICAL PARAMETERS

Colour

Throughout the study period colour readings rarely exceeded 5 (expressed as Hazen Units). However in July and August colour values for depths of 10.0 and 11.6 m showed a marked increase (July 23 - 15 Hazen units for the 10.0 and 11.6 m depths were 45 Hazen Units).

Turbidity

Turbidities expressed in Formazin Turbidity Units are summarized in Table 1. There was no trend in vertical distribution of turbidity. These results could not be compared to turbidity values (expressed as Jackson Turbidity Units) of Michalski and Hopkins (1970).

Temperature

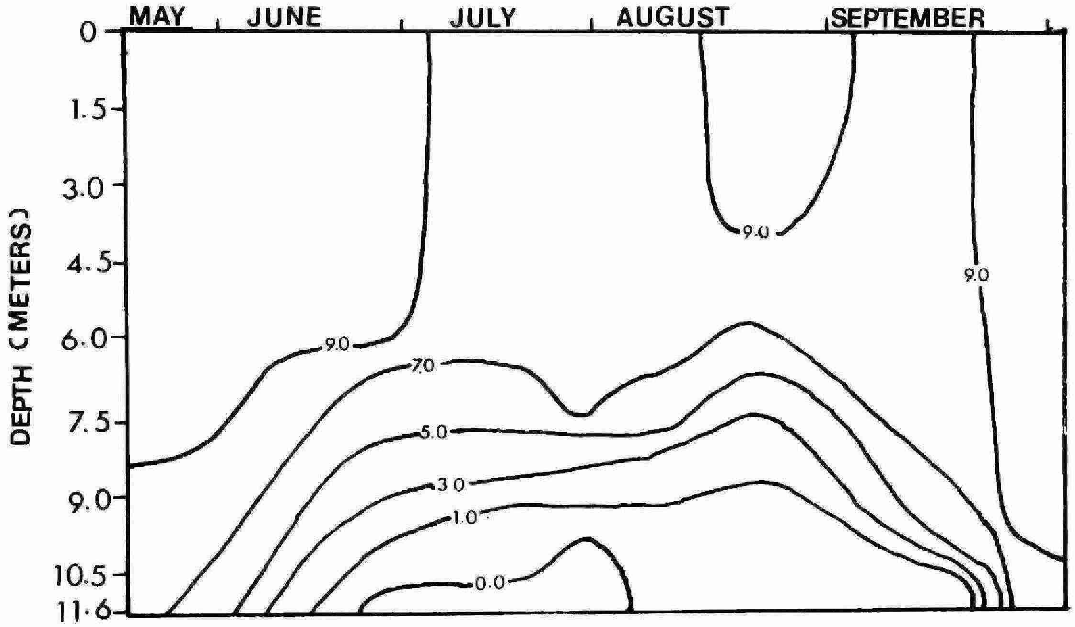
Throughout the study period there was no development of a distinct thermocline. The greatest range of temperature with depth was present on July 23rd when the difference in temperature between surface (24°C) and bottom (12°C) was 12°C (Figure 2).

Table 1. Summary of turbidity values (expressed in Formazin Turbidity Units) at deep water station, Roblin Lake, May 16th - October 1st, 1974.

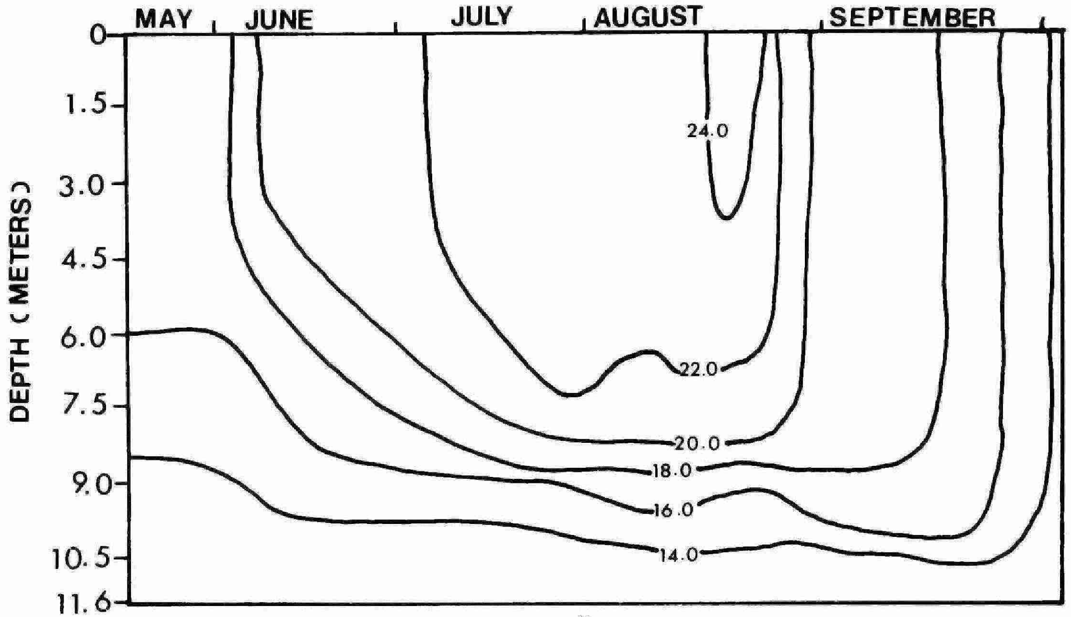
Depth (meters)	Number of Analyses	Maximum	Minimum	Mean
SURFACE	11	3.6	0.95	1.6
2.0	11	2.4	0.95	1.6
4.0	11	2.7	0.93	1.7
6.0	11	2.7	0.81	1.6
8.0	11	1.8	0.72	1.3
10.0	11	4.0	0.80	1.9
11.6	9	2.8	0.88	1.7

FIGURE: 2

DISSOLVED OXYGEN ISOPLETH AND ISOTHERM AT
DEEP WATER STATION
ROBLIN LAKE MAY 16 – OCT 1, 1974



DISSOLVED OXYGEN (mg/l)



TEMPERATURE (°C)

Water Transparency

Secchi disc values ranged from a high of 5.9 m on June 11th to a low of 2.6 m on August 7th with a seasonal average of 3.8 m. (Figure 3). Water transparency showed a slight improvement from the average value of 3.2 m of Michalski and Hopkins (1970).

BIOLOGICAL PARAMETERS

Chlorophyll a

Representative chlorophyll a values through the euphotic zone on each sampling date are shown in Figure 3. Chlorophyll a values ranged from 0.4 ppb to 3.1 ppb and correlated reasonably well with the Secchi disc readings ($r = .65$).

CHEMICAL PARAMETERS

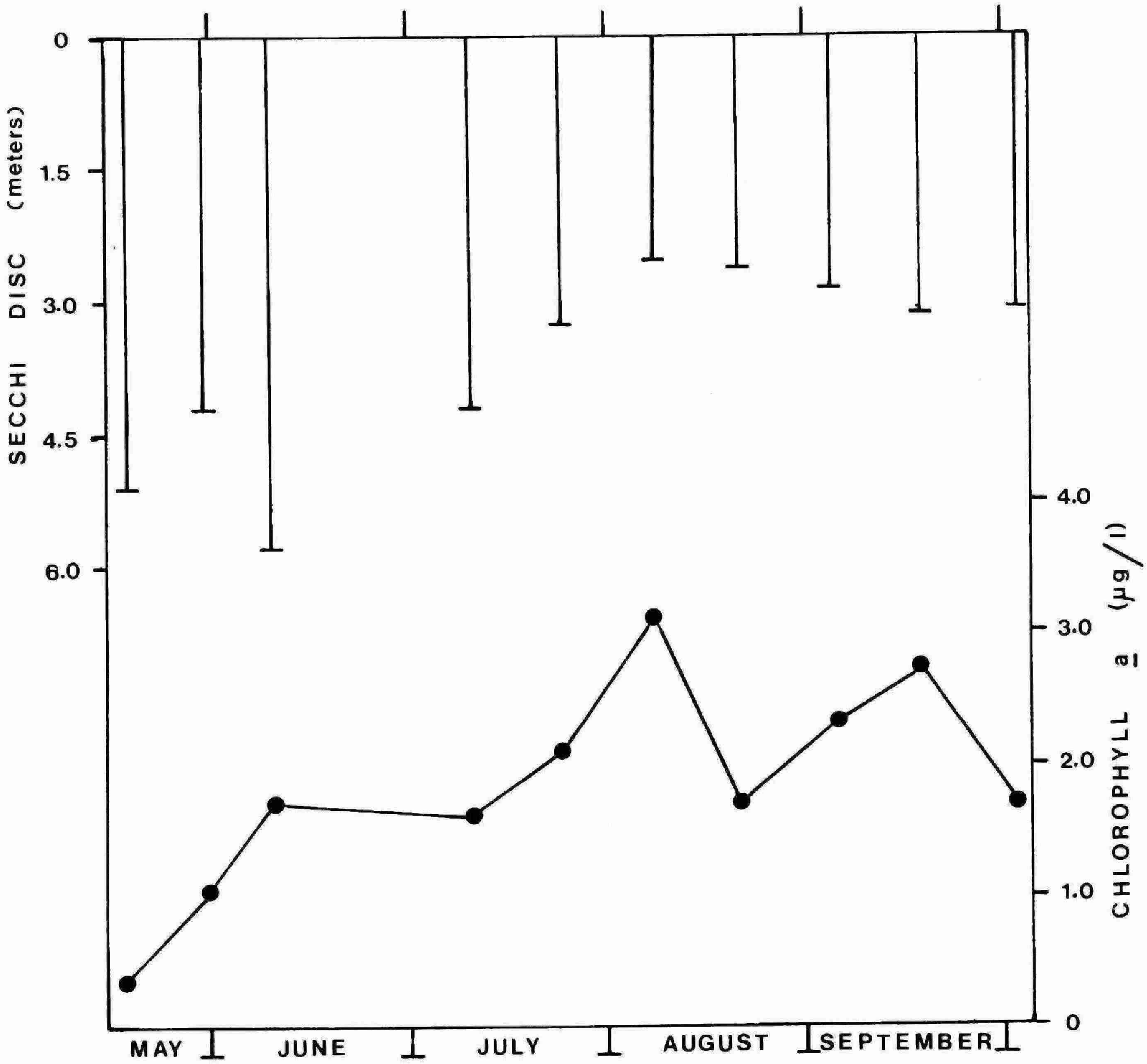
General

Seasonal isopleths for hardness, alkalinity and conductivity are summarized in Figures 4a, b and c.

In all three parameters homogeneous values with depth were seen on the first (May 16th) and last day of sampling (October 1st) paralleling the occurrences of spring and fall turnover respectively. In mid-summer these parameters decreased in the surface waters while correspondingly increasing in the bottom waters. Sodium, potassium and chloride determinations were 2.5, 2.4, and 5.7 mg/l respectively with no seasonal or vertical variations.

Dissolved Oxygen

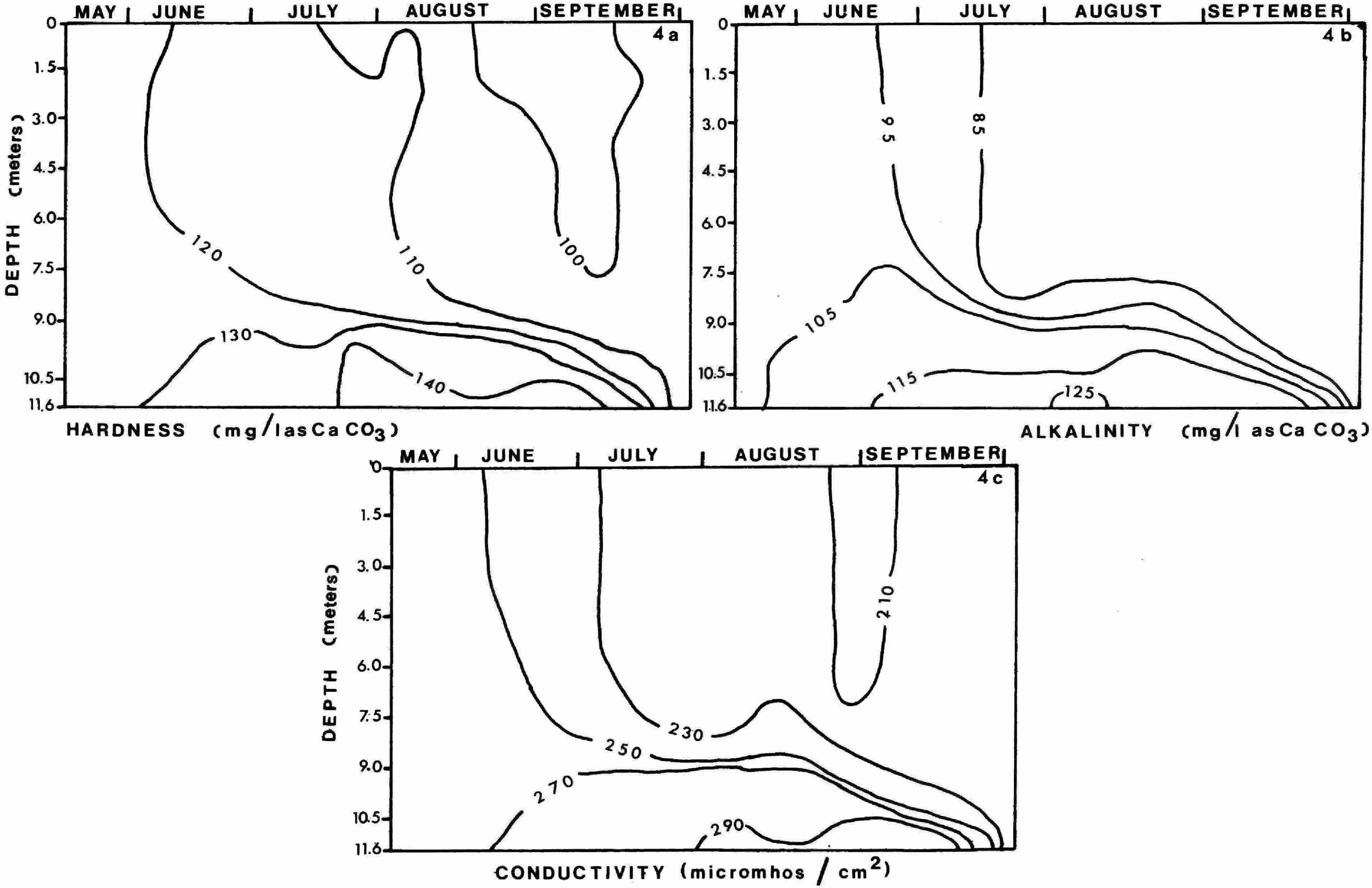
Clinograde oxygen distributions were evident on all sampling dates. Oxygen in the bottom waters showed a progressive reduction until June 25th when no oxygen was present at the 11.6 m depth (Figure 2). By July 23 no dissolved oxygen was evident at the 10.0 m depth as well. From this date onward oxygen concentrations increased in the bottom waters until October 1st when there was very little difference between values at the surface



FIGURE; 3

SEASONAL SECCHI DISC READINGS WITH AVERAGE EUPHOTIC ZONE CHLOROPHYLL a VALUES

FIGURE; 4
ISOPLETHS OF HARDNESS, ALKALINITY AND CONDUCTIVITY AT DEEP WATER STATION, ROBLIN LAKE MAY 16 – OCT. 1, 1974



and the bottom presumably due to fall turnover.

pH

Generally pH values decreased with depth. Considering the entire sampling period pH values ranged between 8.7 at the surface and 7.0 at a depth of 11.6 m.

Iron

Iron values rarely exceeded 0.05 mg/l with the exception of the 11.6 m depth in September with values of 0.15 and 0.10 mg/l respectively. On October 1st iron values of 0.10 mg/l were evident at depths of 2.0, 4.0 and 8.0 m while all other depths had values that did not exceed 0.05 mg/l. Michalski and Hopkins (1970) observed iron values greater than 0.20 mg/l from a depth of 4.6 m to the bottom on September 30th.

Nutrients

Table 2 summarizes the nutrient data for Roblin Lake. Both the total phosphorus and total Kjeldahl nitrogen showed increases in concentration with depth. Silica levels remained relatively homogeneous throughout the sample depths with the exception of values at 11.6 m which were somewhat higher. Likewise, ammonia levels remained relatively homogeneous with depth with the exception of values recorded at depths of 10.0 and 11.6 m which showed high levels associated with the decomposition of organic material on the sediment.

Relative to the data of Michalski and Hopkins (1970) mean total phosphorus values were rather close to, or slightly higher than data given for 1970. Silica values in the present study were considerably higher. Total Kjeldahl nitrogen was lower through the water column in the present study but higher at the 10.0 m depth. Free ammonia values paralleled very closely with the 1970 data at all depths. Comparative data of Michalski and Hopkins (1970) is presented in Table 3.

Table 2. Summary of nutrient determinations (expressed in mg/l) made on samples collected from deep water station, Roblin Lake, on eleven dates between May 16th and October 1st, 1974.

Depth (meters)	Total Phosphorus (as P)		Total Kjeldahl Nitrogen		Silica as SiO_2		Free Ammonia (as N)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Surface	0.009-0.027	0.015	0.50-0.70	0.58	0.5-2.9	2.0	0.01-0.07	0.04
2.0	0.010-0.049	0.017	0.45-0.71	0.57	0.6-3.0	2.1	0.01-0.08	0.04
4.0	0.007-0.034	0.016	0.51-0.71	0.61	0.6-2.9	1.9	0.01-0.05	0.04
6.0	0.008-0.028	0.017	0.47-0.67	0.57	0.8-2.9	2.0	0.01-0.06	0.04
8.0	0.009-0.045	0.020	0.47-0.69	0.59	0.6-3.0	2.0	0.01-0.16	0.06
10.0	0.010-0.027	0.021	0.50-1.40	0.81	0.9-3.3	2.4	0.06-0.41	0.20
11.6	0.013-0.080	0.031	0.55-2.40	1.40	1.1-4.8	3.1	0.10-2.10	0.67

Table 3. Summary of nutrient determinations (expressed in mg/l) made on samples collected from Station A, Roblin Lake on five dates between June 6 and September 30, 1970.

Depth (feet)	Total Phosphorus (as P)		Orthosilicate (as SiO_2)		Total Kjeldahl Nitrogen		Free Ammonia (as N)	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
1	0.014	0.011-0.020	1.45	0.39-2.30	0.63	0.50-0.76	0.04	0.02-0.11
7	0.013	0.010-0.016	1.44	0.38-2.40	0.69	0.47-0.87	0.04	0.02-0.05
13	0.014	0.009-0.020	1.39	0.35-2.30	0.60	0.45-0.72	0.03	0.02-0.08
20	0.013	0.010-0.019	1.30	0.23-2.40	0.66	0.57-0.80	.05	0.02-0.10
26	0.015	0.010-0.020	1.23	0.21-2.10	0.68	0.59-0.76	0.08	0.04-0.16
33	0.025	0.012-0.043	1.58	0.30-2.30	1.12	0.62-1.80	0.27	0.07-0.75

Bacteriological Conditions

Bacteriological data with geometric means are shown in Table 3. Throughout the sample period all depths were characterized by low total and fecal coliforms.

Table 4. Individual bacteriological analyses completed (Total Coliform /100 ml and Fecal Coliform /100 ml) on samples taken from deep water station in Roblin Lake and summary of the data (Geometric Mean).

Depth (meters)	June 10		July 23		August 20		September 17		G.M.	
	TC	FC	TC	FC	TC	FC	TC	FC	TC	FC
Surface	40	1	20	-	12	4	1	1	9.9	1.4
2.0	20	4	8	-	20	1	1	1	7.5	1.4
4.0	40	1	36	1	32	8	1	1	14.7	1.7
6.0	10	1	16	1	12	1	1	1	6.6	1.0
8.0	30	1	36	1	52	1	40	1	38.7	1.0
10.0	20	1	16	1	4	1	1	1	6.0	1.0
11.6	-	-	1	1	-	1	1	1	1.0	1.0

DISCUSSION

Michalski and Hopkins (1970) in evaluating the enrichment status of Roblin Lake concluded that classical indications of mesotrophy and/or eutrophy were evinced by relatively low Secchi disc readings, oxygen depletions and high phosphorus, nitrogen and iron concentrations in the deeper water; depression of pH in the deeper strata and by relatively high standing stocks of phytoplankton dominated by the blue-green "water bloom" alga Microcystis. Comparatively speaking, Roblin Lake with an average Secchi disc reading of 3.8m was substantially lower than oligotrophic Lake Joseph (7.6m unpublished OWRC data) and slightly lower than oligotrophic Lake Bernard (4.1m Michalski and Robinson, 1969). Roblin Lake compares exactly with mesotrophic Silver Lake (3.8m Michalski and Robinson, 1969). Roblin Lake has an average Secchi disc reading much higher than eutrophic Riley Lake (1.6m Michalski and Robinson, 1970).

Figures 5 shows that Roblin Lake with an estimated loading of 0.117 gms total P m^{-2} yr^{-1} and a mean depth of 3.1m along with a flushing time of 2.8 years is classified as mesotrophic according to Vollenweiders total phosphorus loading - mean depth ($\bar{z}$) divided by flushing time (τ_w) relationship (Vollenweider, 1973). This coincides with the conclusion of Michalski and Hopkins (1970).

In terms of the parameters evaluated it is apparent that the enrichment status of Roblin Lake has shown very little change since 1970.

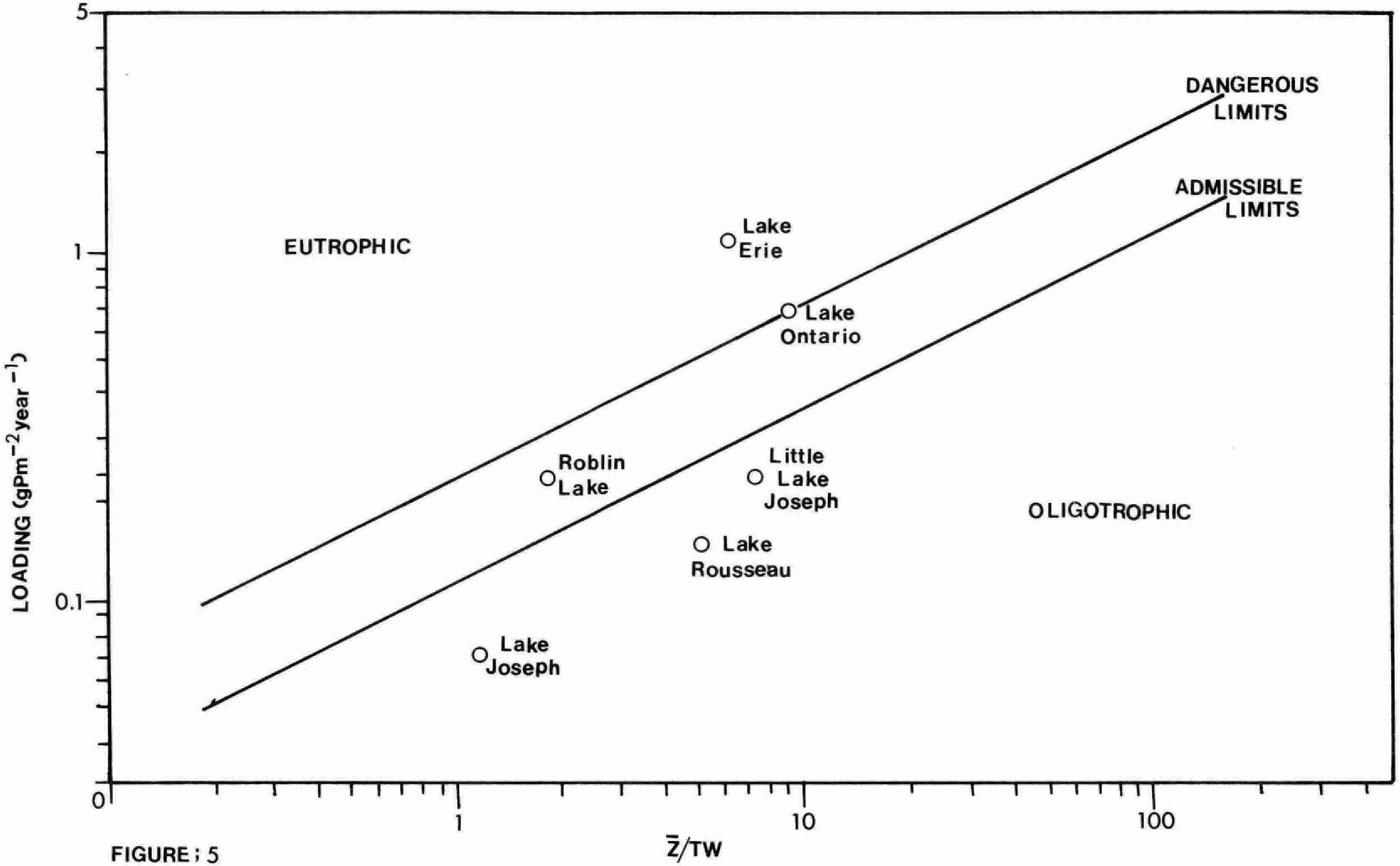


FIGURE ; 5

Annual total phosphorus loading vs $\bar{Z}$/TW for Roblin Lake relative to other selected lakes. Lakes above the upper diagonals are eutrophic in status, while lakes below the diagonals are oligotrophic. Lakes between the diagonals are mesotrophic.

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APPENDIX A

Calculation of phosphorus loading for Roblin Lake

1) Natural phosphorus loading

$$J_E = \Sigma(Ad.E_i) \qquad E_i = 23.3$$

$$= \Sigma(2.38 \times 10^6 \times 23.3) \qquad Ad = 2.38 \times 10^6 m^2$$

$$= 55.5 \times 10^6 mgPyr^{-1} \quad \text{or} \quad 55.5\ kg\ Pyr^{-1}$$

* $$J_{PR} = 35 \cdot A_0$$

$$= (35)\ (0.85 \times 10^6)$$

$$= 30 \times 10^6 mg\ Pyr^{-1} \quad \text{or} \quad 30.0\ kg\ Pyr^{-1}$$

$$J_N = J_E + J_{PR}$$

$$= \Sigma(Ad.E_c) + 35 \cdot A_0$$

$$= 55.5 + 30.0 = 85.5\ kg\ Pyr^{-1}$$

2) Artificial phosphorus loading

$$J_A = \left(\frac{0.4\ kg}{capita\text{-}year} \times N\ cottages \times \frac{T\ capita\text{-}year}{cottage\text{-}year} \right)$$

$$J_A = 0.4 \times 50 \times 0.69 = 13.8\ kg\ Pyr^{-1}$$

3) Total P Supply to lake

$$J_T = J_N + J_A$$

$$= 85.5 + 13.8 = 99.3\ kg\ Pyr^{-1}$$

4) Loading $= {}^{J_T}/_{A_0} = 99.3/8.5 \times 10^5 = 0.117\ gms\ Pm^{-2}yr^{-1}$

Calculation of flushing rate

r = 1.1
Pr = 33"
Ev = 27"

$$Q = Ad.r + A_0(Pr-Ev) \qquad Ad = 2.38 \times 10^6 m^2$$

$$= 2.56 \times 10^7(1.1) + .92 \times 10^7(.5) \qquad = 2.57 \times 10^7 ft^2$$

$$= 2.82 \times 10^7 + .46 \times 10^7 \qquad A_0 = 0.85 \times km^2$$

$$= 3.28 \times 10^7 ft^{-3} yr^{-1} \qquad = 0.92 \times 10^7 ft^2$$

$$P = {}^{Q}/_{V} = \frac{3.28 \times 10^7}{9.2 \times 10^7} = 0.36\ yr^{-1}$$

Flushing time $^{V}/_{Q} = \dfrac{9.2 \times 10^7}{3.28 \times 10^7} = 2.8$ years

$$q_s = {}^{\bar{z}}/_{Tw} = {}^{3.05}/_{2.8} = 1.09$$

*Revised estimation of phosphorus input via precipitation (W. Scheider (pers. comm.))